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Answer Key: Dissecting Vector Kinematics: 10th Grade Physics Challenge

Can you predict the trajectory of an accelerating particle? Synthesize motion equations to resolve complex one-dimensional displacement and velocity problems.

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1. A hyper-loop pod traveling at 120 m/s undergoes a constant deceleration of 8.0 m/s². To calculate the distance required for the pod to reach a complete stop, which kinematic relationship is most efficient?

Answer: C) $v^2 = u^2 + 2a\Delta x$

Since time (t) is neither given nor required, the third kinematic equation allows for direct solving of displacement using initial velocity, final velocity, and acceleration.

2. If an object's velocity is zero at a specific instant, its acceleration at that same instant must also be zero.

Answer: B) False

Consider a ball thrown vertically; at its peak, velocity is zero, but it still experiences a constant gravitational acceleration of 9.8 m/s² downward.

3. A drone launches from a platform and accelerates from rest at a rate of 4.5 m/s² for exactly 6.0 seconds. The total displacement of the drone during this interval is ___ meters.

Answer: C) 81.0

Using $\Delta x = ut + \frac{1}{2}at^2$: with u=0, $\Delta x = 0.5 * 4.5 * (6.0)^2 = 0.5 * 4.5 * 36 = 81$ meters.

4. A maglev train travels 200 km West, then 150 km North, and finally 200 km East. What is the magnitude of the train's total displacement?

Answer: C) 150 km

Displacement is a vector. The West and East movements cancel each other out (200 - 200 = 0), leaving only the 150 km North component as the resultant displacement.

5. An experimental rocket car starts from rest and reaches a velocity of 100 m/s over a distance of 400 meters. What is the magnitude of its constant acceleration?

Answer: A) 12.5 m/s²

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Using $v^2 = u^2 + 2as$: $100^2 = 0^2 + 2(a)(400)$ gives $10000 = 800a$. Solving for a yields 12.5 m/s^2.

6. A particle moves along a straight path. If its position function is defined by a quadratic equation of time ($x = At^2 + Bt$), the acceleration of the particle is ___.

Answer: B) Constant

In 1D kinematics, position is a quadratic function of time only when acceleration is constant (as seen in $\Delta x = ut + \frac{1}{2}at^2$).

7. An object traveling with a negative velocity and a negative acceleration is currently slowing down.

Answer: B) False

When velocity and acceleration have the same sign, the object is speeding up in that direction. It only slows down when the signs are opposite.

8. Which of the following scenarios describes a situation where the average velocity is exactly zero over a specific time interval?

Answer: A) A race car completing one full lap around a circular track.

Average velocity is calculated as total displacement divided by time. Completing a lap means the starting and ending positions are the same, resulting in zero displacement.

9. On a velocity-time graph, a horizontal line located at v = -5 m/s represents an object that is ___.

Answer: A) Moving at a constant speed in the negative direction

A horizontal line on a v-t graph indicates constant velocity (zero acceleration). The negative value signifies the direction of travel.

10. A projectile is launched horizontally. If air resistance is neglected, the horizontal component of its velocity remains constant because:

Answer: A) Gravity only acts in the vertical dimension.

In 2D kinematics, vertical and horizontal motions are independent. Since the force of gravity is purely vertical, there is no horizontal force—and thus no horizontal acceleration.